[Proc. Roy. Soc. Victoria, 40 (N.S.), Pt. I., 1927.]

Art. I.—*Anatomy of Australian Coniferous Timbers.*

By R. T. PATTON, B.Sc., M.F.

(With Plates I.-V.)

[Read 10th March, 1927.]

Introduction.

The conifers of Australia are unique in many respects, as has often been remarked, and are on the whole widely different from those of the Northern Hemisphere. The large and well-known tribe, Abietineae, is entirely absent from Australia, and associated with this is the entire absence of such characters as the fusiform ray, the ray tracheide, and the resin canal. On the other hand, the resin tracheide, which is entirely absent from the above mentioned tribe, appears in two of our genera, *Agathis* and *Araucaria*, belonging to the tribe Araucarineae, which is almost exclusively southern.

Owing to the difficulty in obtaining some of our isolated species a long time has elapsed since this work was begun. Specimens of all the genera have been obtained, but the following species have not been received: *Callitris Roei* Endl., *C. Morrisoni*, R.T.B., *C. Drummondii* Benth. et Hook., *Actinostrobus acuminatus* Parlat., and *Podocarpus Drouyniana* F.v.M.

Although the work is not complete, it has been decided to publish what has been done owing to many requests for information regarding the structure of our conifers. The structure of the commercial coniferous timbers of Australia has been studied by Baker and Smith (1), but these authors did not investigate the non-commercial species. These latter are of interest, however, from a palaeontological point of view. Moreover, these authors have used well recognised terms in somewhat unusual ways. The present work, therefore, has covered all the species obtainable.

For the accompanying photomicrographs I am indebted to Mr. H. Marriott, of the Anatomy Department, University of Melbourne.

Pherosphaera.

This genus is endemic to Australia and Tasmania. One species, *P. Fitzgeraldi* F.v.M., is found in New South Wales, and the other, *P. Hookeriana* Arch., in Tasmania. Both are small shrubs growing in restricted habitats.

Transverse.—Rings fairly well defined, walls thick, lumen of cells of summer wood almost obliterated. Width of cells about 15 μ. Resin cells moderately abundant or absent.

Radial.—Bordered pits uniseriate, occasionally partly biseriate. Pits on the lateral walls of the medullary rays one per tracheide, large, elliptical and oblique.

Tangential.—Medullary rays 1-5 cells high. Pits present on the tangential walls of the tracheides.

Tracheides from 0·7 to 1·3 mm. long.

In *P. Hookeriana* the cells walls are not nearly so thickened as in *P. Fitzgeraldi*. In the former the cells are squarish, with walls 3-5 μ in thickness, but in the latter they are rounded and the walls are 6-8 μ thick. In both species the thickness of the wall throughout the ring is fairly constant. In *P. Fitzgeraldi* pits on the tangential walls are very abundant, but infrequent in *P. Hookeriana*.

Material of both species authenticated by Professor Lawson; material of *P. Hookeriana* from Government Botanist, Tasmania, and from G. Weindorfer, Esq.

Microcachrys.

A monotypic genus endemic to Tasmania, *M. tetragona* Hook. is a small shrub, rare.

Transverse.—Rings rather indefinite; tracheides not very regularly arranged in radial rows; walls thin, squarish. Resin cells absent.

Radial.—Bordered pits uniseriate, indistinct. Lateral walls of medullary rays 1-2 pits per tracheide. These pits are very irregular as regards size and shape; some are large and open without any border, while some are narrow, elongated and bordered. Medullary rays frequently irregular in outline. No parenchyma.

Tangential.—Medullary rays 1-4 cells high, maximum 7. Cells elongated, thin walled.

Material authenticated by Government Botanist, Tasmania, and by G. Weindorfer, Esq., Cradle Mt., Tasmania.

Dacrydium.

There is only one species, *D. Franklinii* Hook. It is an average-sized tree, and is endemic to Tasmania. The genus is also found in the Malay area, New Zealand, and Chile.

Transverse.—Rings narrow, well defined. Summer wood 2-4 cells wide. Spring wood very open, cells usually somewhat hexagonal or rounded. Thickness of walls of spring wood about 8 μ. Tracheides not in regular radial rows. Resin cells absent.

Radial.—Bordered pits uniseriate, not crowded. Medullary rays have the marginal walls somewhat sinuous. Lateral pits on medullary rays one, rarely two, per tracheide, large, elliptical, oblique, narrow or broad. Parenchyma absent.

Tangential.—Medullary rays 3-7 cells high, maximum 13. Cells thick walled. Parenchyma absent.

Material from trade sources and from the Sydney Technological Museum.

In regard to this species Baker and Smith (1) state that one of "the most distinguishing characters of the wood is the fineness of the wall structure." This is by no means the case as their

photograph shows. This statement could well be used in regard to *Athrotaxis*. As a matter of fact the walls are thick and there is very little difference between the thickness of the spring and summer cell walls.

In microscopic section *Dacrydium Franklinii* cannot be satisfactorily distinguished from *Phyllocladus rhomboidalis*. In the latter the pits on the medullary rays are usually larger than in the former, and in the latter also two pits per tracheide are common.

In *Phyllocladus rhomboidalis* the tracheides are more rectangular, seen in cross section, than in *Dacrydium Franklinii*.

Podocarpus.

This genus is represented in Australia by six species, five of which have been studied. The genus is very widespread in the Pacific regions, extending from New Zealand to Japan. In habit they range from dwarf shrubs, as *P. alpina*, to large trees, as *P. elata*.

Transverse.—Growth rings more or less indefinite, the spring wood gradually passing into summer wood, the latter consisting of one to few rows of very narrow cells. Walls thick, cells subrectangular to round, arranged in fairly definite radial rows. Medullary rays resinous or non-resinous. Resin cells present or absent; when present, widely scattering or zoned. This character is widely variable both in Australian and extra-Australian species. Kanehira (4), speaking of *P. philippinensis* Foxworthy says, "Resin cells numerous, often connected tangentially"; while of *P. macrophyllus* Don (5) he says, "Resin cells present rather scarce." Again, speaking of *P. Nagi* Zoll et Moritz, he says, "Resin cells evenly distributed in both early and late wood." The character is not generic.

Radial.—Rays resinous, uniform in character. The outer upper and lower walls somewhat irregular in outline and thicker walled. Inner horizontal walls not strictly parallel. End walls more or less vertical, unpitted, frequently curved. Lateral walls bearing 1-3 bordered pits per tracheide; pit aperture narrow or broad, oblique. Bordered pits uniseriate or incompletely biseriate, and then opposed, not alternate. Pits scattered, generally, but when crowded, indistinct Bars of Sanio are visible. Resin cells conspicuous when present.

Tangential.—Rays uniseriate, moderate in height; cells elliptical to round, thin to thick-walled, sometimes resinous.

This genus with its somewhat rounded cells, scattering resin cells, and single rows of bordered pits, is very similar to *Callitris*. No species of *Podocarpus* has, however, the peculiar plate of thickening across the bordered pits as seen in some species of *Callitris*. The cells of *Callitris*, as seen in transverse section, are always more rounded. In *Podocarpus* the medullary rays never have more than three pits per tracheide.

Podocarpus elata R.Br.

Transverse.—Rings of growth broad, summer wood few cells thick, not very distinct; the cells being about half the width of the spring wood cells. Resin cells abundant, widely scattered.

Radial.—Resin cells conspicuous; rays resinous.

Tangential.—Ray cells resinous, elliptical.

Specimen authenticated by the Sydney Technological Museum.

P. pedunculata Bail.

Transverse.—Rings very indefinite, thin walled. Resin cells absent.

Radial.—Ray cells devoid of resin; resin cells absent. Pits on medullary rays moderately large, widely open.

Tangential.—Medullary rays devoid of resin; cells varying greatly in size; thin walled.

Specimen authenticated by the Technological Museum, Sydney.

P. spinulosa R.Br.

Cells rounded, thick walled; resin cells absent. Rings of growth not determinable. Rays devoid of resin.

Specimen authenticated by the Technological Museum, Sydney.

P. ladei Bail.

Similar to *P. spinulosa*.

Specimen authenticated by Government Botanist, Queensland.

P. alpina R.Br.

Transverse.—Rings very narrow, only a few cells wide, very irregular in width, fairly distinct. Resin cells abundant.

Radial.—Resin parenchyma present. Pits on lateral walls of medullary rays usually two, large, elliptical.

Tangential.—Rays very short, one cell high common, maximum four.

Specimens authenticated by Government Botanist, Tasmania; G. Weindorfer, Esq.; and by the author.

Phyllocladus.

This genus is not found on the mainland of Australia, and our only species, *P. rhomboidalis* Rich., is endemic to Tasmania. The genus is also found in New Zealand and the East Indies. The timber of *P. rhomboidalis* is known commercially as Celery Top Pine.

Transverse.—Rings comparatively narrow, well defined. Summer wood 2-4 cells broad, lumen almost obliterated. Spring wood open, thick walled, rectangular; cells up to 40 μ in length, radially arranged. Resin cells absent.

Radial.—Bordered pits uniseriate, not crowded, often scattered; no Bars of Sanio present. Resin cells absent. Upper and lower walls of the medullary rays straight or slightly sinuous, outer walls thinner than the inner. Pits on the lateral walls 1-2 per tracheide, large, oblique, elliptical, faintly bordered. Occasionally the aperture is narrow and then it is distinct.

Tangential.—Medullary rays generally 4-12 cells high, maximum 20. Cells elliptical, thin walled. Bordered pits on the tangential walls.

Authenticated material from the Sydney Technological Museum, and from trade sources.

In regard to this species Baker and Smith (1) say, "Similar anatomical characters" to those of *Dacrydium Franklinii*. This is so. These authors would separate the two species by the presence of bordered pits on the tangential walls of *Phyllocladus rhomboidalis*, and their absence from *Dacrydium Franklinii*. This does not hold absolutely.

Agathis and Araucaria.

Agathis is represented in Australia by three species, only one of which, *A. robusta* C. Moore, Queensland Kauri, is well known. The other two, *A. Palmerstoni* F.v.M., and *A. microstachys* Bail. et White, are also restricted to Queensland, but are confined to the far north of that State.

Araucaria is represented by two species. One, *A. Cunninghamii* Sweet, which extends down from Queensland into the north-eastern part of New South Wales, gives the well known Hoop Pine of commerce. The other, *A. Bidwilli* Hook., is confined to Queensland. It may be noted that all these five species are restricted to the coastal regions of North-Eastern Australia.

Botanically these two genera are very definite, but microscopically the timbers are very similar. Penhallow (2) sought to distinguish the two genera by the distinctness of the annual rings and for *Araucaria* he states, "Growth rings not determinable," and for *Agathis* he says, "Growth rings obvious but poorly defined." The definiteness of the growth rings is not a generic character, and Penhallow himself, under *Araucaria Bidwilli*, states, "Growth rings broad, poorly defined," almost the same words as for the genus *Agathis*. Baker and Smith would separate the two genera by means of the presence or absence of resin in the medullary rays. They say (1, p. 329) that this "is an important generic, specific and phylogenetic character." An examination of Baker and Smith's own material, however, shows that this substance is present in all species. Baker and Smith themselves, under *A. Bidwillii*, say, *loc. cit.*, "The medullary rays have their cells filled with the brown or dark substance." It is true that resin is far more plentiful in *Agathis* than in *Araucaria* as a general rule, but *Araucaria Bidwillii* contains more resin than *Agathis Palmerstoni*. Baker and Smith also attempt to separate these two genera by the

absence of bordered pits from the tangential walls of species of *Agathis*. This latter genus, however, has pits on the tangential walls just as has *Araucaria*. Kanehira (4) notes pitting on the tangential walls of *A. alba*. Pitting on the tangential walls is a character easily overlooked.

It has been found impossible by the author to find a single character that will separate the two genera. In the hand specimen, kauri timbers are somewhat denser, and usually darker, due to a greater amount of resin present, than Araucarian timbers. The darkness of the timbers is shown by *A. australis* Steud (New Zealand), *A. robusta* (C. Moore) F.v.M. (Queensland), *A. microstachys* Bailey et White (Queensland), and *A. lanceolata* Panch.et Sebert (New Caledonia). In all these the rays are dark coloured, but in *Agathis Palmerstoni* they are light coloured. The timber of the various species of *Araucaria* is usually light coloured. The rays are slightly darker, due to the presence of some resin. The timber of *A. Bidwilli*, however, is very dark, and in this respect approaches a kauri.

Transverse.—The tracheides are thick walled and vary from hexagonal to circular in shape. The tracheides are arranged in fairly definite rows. The annual rings are not conspicuous, and the summer wood may be reduced to a single row. Alongside the medullary rays resinous tracheides are more or less common. They are much more frequent in *Agathis* than in *Araucaria*. However, Kanehira (4) notes that in *Agathis alba* (Lamarck) Foxworthy, "Resin cells normally absent." In the only specimen of *Agathis Palmerstoni* obtainable, the resin tracheides were also absent. In *Agathis microstachys* they are scattered, not radially arranged along the medullary rays. Medullary rays usually resinous, particularly in *Agathis*.

Radial.—As is common in other Australian genera, the ray cells are all of one kind. The conspicuous feature of the rays is their irregular shape. They are more or less conspicuously contracted at the ends, and at times the end wall is obliterated. This character was observed by Penhallow (2) in the species of both genera which he studied. The character is, apparently, common to all species. It is not commented on by either Jeffry (6) or Baker and Smith (1). It was noted by Jones (3). The walls of the ray cells are thin, and do not show any local thickening. The lateral walls bear a varying number of bordered pits, where in contact with a tracheide. They range from 2 to 12 in number.

A conspicuous feature of the resin tracheides is the presence of resin plates across the cells. These are more abundant near the medullary rays. These plates are fully discussed by Penhallow (2), and they give a pseudo-parenchymatous appearance to the tissue. They vary in thickness, some are uniformly thin, others are very thick where in contact with the cell wall and narrow towards the centre. Usually the plate is entire, but it may have a small perforation at the centre. These plates were also noted by Jones (3), but they are not mentioned by Jeffry (6), who, how-

ever, does mention parenchyma. In no species studied has any parenchyma been found. The bordered pits on the radial walls range from one to four rows, the pits in each row alternating, and when crowded have an hexagonal outline. In *Agathis robusta* and *Agathis Palmerstoni*, where extra broad tracheides occur, there is an irregularity of the four rows, and a fifth row is possible. The opening of the pit is usually oblique.

Tangential.—Medullary uniseriate, rather low, averaging from three to twelve cells high. Cells oval, resinous. Resin plates conspicuous, when present. Pitting on the tangential walls common to all species. The pits may be either large or small.

Agathis robusta (C. Moore) F.v.M.

Transverse.—Rings poorly defined, summer wood 2-4 cells wide. Resin tracheides bordering the medullary rays plentiful, a few scattered. Rays resinous.

Radial.—Bordered pits 2-4 seriate, four rows abundant; aperture circular. Medullary rays resinous; 2-8 pits per tracheide; aperture oblique, narrow. Resin plates abundant.

Tangential.—Rays uniseriate, 3-15 cells high, maximum 25. Pits present on the tangential walls.

The two conspicuous features of this timber are the presence of four rows of bordered pits, and the abundance of resinous tracheides. Baker and Smith (1) state in regard to this timber, "... xlyem tracheides are also devoid of this substance (i.e., resin) ... one that differentiates the timber from *Araucaria*." The resinous tracheides are, however, abundantly present. Again (p. 377) they state, "The large number (up to twelve) of simple cells between the walls of the lumina is also a good diagnostic character of the genus." Note the curious use of the word "cell," where evidently pit is intended. The large number of pits is also found in *A. microstachys*.

Authenticated material from Sydney Technological Museum and from trade sources.

Agathis microstachys Bailey et White.

Transverse.—Rings poorly defined, 2-4 rows of summer tracheides. Resin tracheides common, scattered, not occurring along the rays. Medullary rays resinous.

Radial.—Bordered pits 1-2 seriate, occasionally three, aperture narrow, oblique. Ray cells conspicuously contracted, very resinous. Pits on the medullary rays 2-5 per tracheide, rarely more; bordered, aperture oblique.

Tangential.—Rays uniseriate, 4-12 cells high, maximum 19. Cells thin walled, round. Resin plates plentiful. Pits on tangential walls. Authenticated material from Government Botanist, Queensland.

Agathis palmerstoni F.v.M.

Transverse.—Medullary rays only slightly resinous. Resinous tracheides absent.

Radial.—Bordered pits 1-4 rows, 3-4 rows frequent, aperture circular. Resin in the medullary rays very infrequent; pits on lateral walls of rays 3-12 per tracheide, aperture oblique. Resin plates absent.

Tangential.—Rays uniseriate, 3-12 cells high, maximum 25. Bordered pits on the tangential walls.

Authenticated material from Queensland Forest Service.

Araucaria cunninghami Sweet.

This timber has been described by Penhallow (2), and there is nothing to add to his description. Baker and Smith (1) state in respect to the resin in the medullary rays, "... almost entire absence," but Penhallow remarks, on the other hand, "somewhat resinous." The resin in the rays is a very variable quantity. Timber grown in the grounds of the University of Melbourne shows no resin in the rays at all. Resin tracheides are also very variable in their occurrence. Some specimens show large numbers, others none. In the timber grown at the University, the resin tracheides are zoned, and none occurs adjacent to and parallel to the rays. In regard to the numbers of rows of bordered pits on the radial walls of the tracheides, Baker and Smith say 2-3, but Penhallow says 1-2. There is very occasionally a third row. A single row is common. Penhallow says that pits on the tangential walls are wanting, but they do occur as noted by Baker and Smith. Penhallow remarks that the rays may be two seriate, but the author has not noted this, and apparently neither did Baker and Smith.

Authenticated material from Queensland Forest Service, Technological Museum, Sydney, Trade Sources, and from known trees.

Araucaria Bidwilli Hook.

This has been described by Penhallow, who separates this timber microscopically from *A. Cunninghamii* by the bordered pits being uniseriate. Both species have biseriate rows of pits. Baker and Smith, speaking of the end walls of the ray cells, state that they are right angled, while Penhallow remarks that the cells are "conspicuously contracted at the ends." The latter character frequently interferes with the direction of the end walls. Baker and Smith give the number of pits on the ray cells per tracheide as 4, while Penhallow gives 3-7. The latter number is correct.

Specimens of this timber grown locally show no resin tracheides at all and there is very little resin in the ray cells. It is apparent that the presence or absence of resin from either the tracheides or the rays is very variable, and that its absence from any particular specimen cannot be taken as a definite character.

Authenticated material from Sydney Technological Museum and from known trees.

Athrotaxis.

This genus is endemic to Tasmania. Of the three species, the only well-known one is *A. selaginoides* Don, which provides the King William Pine of commerce. This is one of the lightest of timbers. The other two are small, and are very restricted in distribution. All three have reddish timber, and in structure they resemble the genus *Sequoia*.

Transverse.—Rings very definite, the summer wood having very thick walls, and very narrow lumen, which is very often less than the thickness of the walls. Spring cells more or less definitely rectangular, several times longer than those of the summer wood. Resin cells present or absent, when present scattered.

Radial.—Border pits uniseriate or biseriate; when biseriate, then opposed, not alternate. Bars of Sanio present. Medullary rays narrow, irregular hastate cells often present when the rays are only one cell high. End walls vertical or oblique, often curved. Lateral walls of rays 1-6 pits per tracheide, bordered. Parenchyma present. Resin in parenchyma present or absent.

Tangential.—Medullary rays variable, in height, short rays common. Cells elliptical, thick walled. Pits on tangential walls of spring wood, common, very small.

A. SELAGINOIDES, Don.

Transverse.—Rings very narrow, up to 60 rings to an inch, usually less than 10 cells wide. Summer wood 2-4 cells, springwood up to 8 cells. Resin cells abundant.

Radial.—Bordered pits frequently two seriate. Bars of Sanio conspicuous. Pits on the medullary rays 2-5 per tracheide. Resin cells prominent.

Tangential.—Medullary rays short, commonly 2-4 cells high, maximum 9, resin cells prominent.

Authenticated material from G. Weindorfer, Esq., and from trade sources.

A. CUPRESSOIDES Don.

Transverse.—Ring broad, comparable to *Sequoia sempervirens*. Cells not as rectangular as in *A. selaginoides*. Resin cells abundant, either in or towards the summer wood.

Radial.—Bordered pits mostly uniseriate. Medullary rays 1-2 pits per tracheide. Resin cells abundant.

Tangential.—Medullary slightly higher than in *A. selaginoides*.

Authenticated material from G. Weindorfer, Esq.

A. LAXIFOLIA Hook.

Transverse.—As in *A. cupressoides*, but resin cells wanting. In young specimens isolated unthickened cells occur as in *Diselma Archeri*.

Radial.—Bordered pits uniseriate. Parenchyma abundant, but no resin present. Traumatic resin parenchyma present in some specimens.

Tangential.—As in *A. cupressoides*.

Authenticated material from G. Weindorfer, Esq., and Government Botanist, Tasmania.

Callitris.

This is the most widespread genus of the Coniferae in Australia, being found in every State, and it has also the greatest number of species. If we exclude the related African forms, which are placed under *Tetraclinis* and *Widdringtonia*, *Callitris* is purely an Australian genus. The species range from shrubs to moderately large trees. The number of species is at present a matter of dispute. Bentham (7) recognised nine species under the synonym *Frenela*, but Baker and Smith (1) recognise at least 17. The respective lists are as follows:—

Baker and Smith.		Bentham.	
Callitris	robusta R.Br.	Frenela	robusta A. Cunn.
C.	tuberculata R.Br.	F.	,, var. verrucosa
C.	verrucosa R.Br.	F.	,, ,, ,,
C.	propinqua R.Br.	F.	,, ,, ,,
C.	glauca R.Br.	F.	,, ,, ,,
C.	arenosa A. Cunn.	F.	,, var. microcarpa
C.	intratropica Benth. et Hook.	F.	,, ,, ,,
C.	gracilis R.T.B.		
C.	calcarata R.Br.	F.	Endlicheri Parlat.
C.	rhomboidea R.Br.	F.	rhomboidea Endl.
C.	Tasmanica Baker et Smith	F.	,, var. Tasmanica
C.	Drummondii Benth. et Hook.	F.	Drummondii Parlat.
C.	Roei Endl.	F.	Roei Endl.
C.	Morrisoni R.T.B.		
C.	Muelleri Benth. et Hook.	F.	Muelleri Parlat.
C.	oblonga Rich.	F.	australis R.Br.
C.	Macleayana Benth. et Hook.	F.	Macleayana Parlat.
		F.	Parlatorei F.v.M.

Baker and Smith suppressed one of Bentham's species, *F. Parlatorei*, and created three new ones. It will be noted that Bentham's *F. robusta* was a very comprehensive one, and included no less than seven otherwise recognised species. Undoubtedly these are all closely related. *C. gracilis* R.T.B. is a doubtful species, and is regarded by some as a synonym for *C. propinqua*. Of the remaining nine species given by Baker and Smith, seven are agreed upon by both Baker and Smith on the one hand, and by Bentham on the other. The other two are new. To the above list must be added *C. Baileyi* C. T. White, which is a Queensland species.

Transverse.—Growth rings more or less distinct, but never strongly marked; spring wood passes gradually into the summer wood. Cells thick-walled, almost circular, arranged in radial rows. Resin cells more or less abundant, but never so plentiful as in *Podocarpus,* scattered or somewhat zoned. Medullary rays resinous.

Radial.—Bordered pits uniseriate, at times incompletely biseriate, scattered. Medullary rays strongly resinous, horizontal walls parallel, end walls vertical or oblique or slightly curved. Lateral walls of the rays 2-4 pits per tracheide, aperture oblique. Resin cells present.

Tangential.—Rays uniseriate, height variable. Cells elliptical, resinous.

Callitris robusta.

Under this species, Bentham grouped among others the five species of R. Brown, *C. robusta, C. verrucosa, C. propinqua, C. glauca, C. tuberculata,* Much confusion at present exists as to nomenclature. As originally understood by Brown, *C. robusta* was a West Australian species, but Victorian trees with large cones have been placed under it. Timber specimens of all the foregoing, except *C. tuberculata,* have been obtained, and numerous specimens from commercial sources have also been received. These all show without exception, structures which are very definite and characteristic. In radial section, each bordered pit is associated with a more or less rectangular plate of thickening, extending across the tracheide, beyond the margins of the pit, but not reaching to the upper or lower margin, as seen in Fig. 1*a,* These bands are connected to the tracheidal walls. The aperture of the pit lies within the band. In tangential section these bands appear as projecting awns as seen in Fig. 1*b*. The awns arise at the top and bottom of the aperture of the pit. Another feature seen in radial section is the peculiar compound pit (Fig. 1*c*) connecting the medullary rays with the tracheides. The pit is sub-

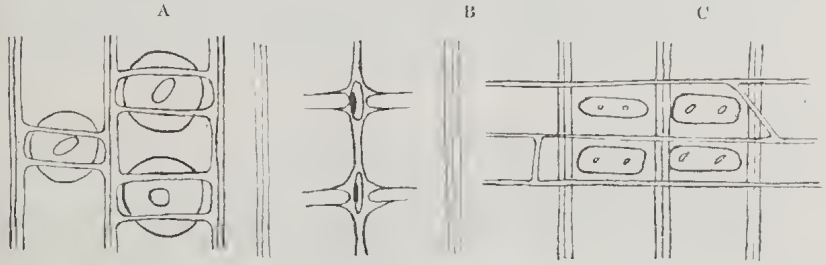

Fig. 1.

rectangular, the length being in the radial direction. The pit is not always parallel to the length of the ray cell, but may be slightly oblique. There are from one to four apertures connecting a tracheide with a ray cell, but there are never more than two aper-

tures in these peculiar compound pits. Whenever in the four species mentioned above, the bands of thickening are found on the bordered pits of the tracheides, the compound pits are found on the ray cells.

In *C. arenosa* A. Cunn. and *C. intratropica* Benth. et Hook., as understood by Baker and Smith, and which were placed under *C. robusta* as var. *microcarpa* by Bentham, the bands across the bordered pits on the radial tracheidal walls are sparsely present, but the double pits on the medullary ray cells are absent. Although Bentham reduced these two species to varieties of *C. robusta*, some botanists to-day regard *C. intratropica* as a valid species, but would suppress *C. arenosa*, making it a synonym of the former. In both of these, the resin cells as seen in cross section, are congregated in the autumn wood; so that here the resin cells may be regarded as zoned as distinct from the scattering cells of the preceding group. The two species, *C. arenosa* and *C. intratropica*, differ from one another in the height of the medullary rays. In *C. arenosa* the rays are shorter than in the former group, rays of 2, 3 and 4 cell high being common. On the other hand, the rays of *C. intratropica* are very elongated, a fact noted by Baker and Smith. The rays generally range from 7 to 25 cells high, but the maximum is 33. In the first group the rays are usually from 4 to 10 cells high.

C. gracilis was not seen, but a tangential microphotograph (rather imperfect), Fig. 127, given in Baker and Smith's work, suggests that the awns are present. This species is regarded by some as a synonym of *C. propinqua*, and in this the awns do occur. *C. calcarata* was recognised as a distinct species by Bentham, and by Baker and Smith. The rays are slightly longer than in the first five species discussed, although Baker and Smith state that the reverse is the case. The rays generally range from 5 to 14 cells high.

C. Baileyi, the most recent species to be described, does not differ in any material way from the robusta group.

The thickening band is absent from *C. Muelleri*, *C. oblonga*, *C. Maclcayana*, *C. rhomboidea* and *C. Tasmanica*. This character, therefore, serves as a useful guide in the classification of the genus.

C. Muelleri has very short medullary rays, a fact noted by Baker and Smith. The rays are usually from 2 to 4 cells high, the maximum being 10.

C. oblonga also shows short medullary rays. In this case they are shorter than those of *C. Muelleri*, being from 1 to 4 cells high.

C. rhomboidea has also short medullary rays. Its structure does not in any way differ from the preceding. *C. Tasmanica*, which some regard as a synonym for *C. rhomboidea*, has longer medullary rays. They are usually from 3 to 7 cells high, maximum 13.

C. Macleayana is a most distinctive tree, but its timber does not show any marked character.

The three West Australian species, *C. Drummondii, C. Roei* and *C. Morrisoni,* were not studied by Baker and Smith, and no material has been available for this study.

Material of *C. robusta, C. verrucosa, C. propinqua,* and *C. glauca* from Sydney Technological Museum, and from the author's collection. *C. arenosa, C. intratropica, C. gracilis, C. calcarata, C. rhomboidea, C. Tasmanica* and *C. Macleayana.* from Sydney Technological Museum. *C. Muelleri* from the Government Botanist, N.S.W., *C. Baileyi* from the Government Botanist, Queensland, *C. oblonga* from Tasmania, but not authenticated.

Actinostrobus.

This genus is very closely allied to *Callitris,* and Mueller suppressed it, and placed its two species under that genus. The two species are confined to West Australia, and both are shrubs. Specimens of *A. pyramidalis* Miq. have been authenticated by the Forestry Department, W.A., but no material of *A. acuminatus* Parlat. has been available. In structure the timber is indistinguishable from *Callitris.* Resin cells are plentiful in the transverse section, and are generally zoned. They are usually in the summer wood. In radial section the medullary rays shows a strong tendency to be contracted at the ends. There is a strong indication of this in some species of *Callitris,* but it is never marked. End walls frequently oblique, often curved. There are from 2 to 4 pits per tracheide on the medullary rays. There is no indication of the plate of thickening on the bordered pits.

Diselma.

This genus was established by Hooker in 1859. It is monotypic, and is confined to Tasmania. Bentham (7) followed Hooker in his determination, but subsequently in 1880 Bentham and Hooker in their Genera Plantarum suppressed this genus, and placed the solitary species under *Fitzroya. Diselma Archeri* Hook. is a shrub.

Transverse.—Rings narrow, well defined. Cells in the spring wood rounded, thick-walled; in the summer wood almost closed; radially arranged. Some cells which are conspicuously rectangular, appear to be larger than the others. Their apparent large size is due to the fact that no secondary thickening has taken place. Rays more or less resinous.

Radial.—Bordered pits uniseriate, aperture oblique. Medullary rays often irregular, cells sometimes arrow shaped (Fig. 2*a*), directed towards the exterior. Cells similar to this are figured by Jones (3) for *Sequoia sempervirens.* Lateral pits 2-4 per tracheide. End walls at times very strongly pitted. Lateral walls

simply pitted. Parenchyma present, devoid of resin; transverse walls often strongly thickened at the centre, vertical walls, simply pitted when parenchyma cells are next to one another.

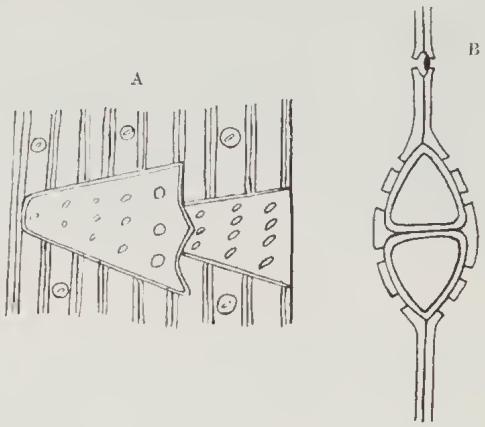

Fig. 2.

Tangential.—Medullary rays uniseriate, 1-4 cells high, one and two cells predominating. Cells elliptical, thick-walled, conspicuously pitted (Fig. 2*b*). Pits present on the tangential walls.

Tracheides.—Very short, 0·5 to 0·8 mm. long.

Material authenticated by G. Weindorfer, Esq., and Government Botanist, Tasmania.

Bibliography.

1. R. T. Baker and H. G. Smith. A Research on the Pines of Australia.
2. D. P. Penhallow. North American Gymnosperms.
3. W. S. Jones. The Structure of Timbers.
4. R. Kanehira. Identification of Philippine Woods by Anatomical Characters.
5. R. Kanehira. Anatomical Characters and Identification of Formosan Woods.
6. E. C. Jeffry. Anatomy of Woody Plants.
7. G. Bentham. Flora Australiensis.

Addendum.

Since the above was written another work from the hand of R. Kanehira has been received entitled, "Anatomical Characters and Identification of the Important Woods of the Japanese Empire." In this appear figures of radial sections, from the medullary ray region, of the following endemic Australian species, *Pherosphaera Hookeriana, Dacrydium Franklinii, Microcachrys tetragona, Phyllocladus rhomboidalis, Araucaria Cunninghamii, Athrotaxis selaginoides, Fitzroya Archeri, Callitris rhomboidea* and *Callitris*

glauca. There are also photomicrographs of *Callitris glauca* (radial sections), and *Agathis robusta* (tangential and transverse sections). As the text is in Japanese characters the author is unable to say how far these species have been described. The figures of the two Tasmanian species, *Pherosphaera Hookeriana* and *Fitzroya Archeri* do not agree with the material I have worked with. Since receiving the above publication I have received from Tasmania more material of *Fitzroya Archeri*, and it agrees with the specimens previously obtained. The figure of *Pherosphaera Hookeriana* given by Kanehira is that of *Fitzroya Archeri*. The figure given for *Fitzroya Archeri* is probably that of *Pherosphaera Hookeriana*. The radial sections of *Dacrydium Franklinii* and *Phyllocladus rhomboidalis* are very similar, a fact which has been discussed in the preceding pages.

In the figure of *Callitris glauca* the compound pit on the medullary ray has been shown, and the plates of thickening on the bordered pits of the tracheides are also shown. Neither transverse nor tangential sections are given of any of the species.

EXPLANATION OF PLATES.

Plate I.

Podocarpus elata.—A, Transverse section showing the scattering resin cells and the indistinct boundary of an annual ring. × 80.

B, Radial section, showing the boundary of an annual ring, and resin in the medullary rays. × 80.

C, Tangential section showing the resin cells. × 80.

Plate II.

A, *Athrotaxis cupressoides*. Transverse section showing the resin cells zoned in the autumn wood, and the very strongly marked boundary of the annual ring. × 70

B, *Athrotaxis selaginoides*. Radial section showing the bordered pits arranged in pairs and also Bars of Sanio. × 190.

C, *A. cupressoides*. Tangential section showing the resin cells. × 70.

Plate III.

Diselma Archeri.—A, Transverse section showing the large, unthickened cells, squarish in outline. × 230.

B, Radial section showing parenchyma and arrow-shaped cells of the medullary rays. × 155.

C, Tangential section showing simple and bordered pits and the short medullary rays. × 170.

Plate IV.

Agathis microstachys.—A, Transverse section showing the indefinite boundary of an annual ring and an isolated resin tracheide. × 100.

B, Radial section, showing the irregular nature of the cells of the medullary rays. × 68.

C, Tangential section, showing the alternating hexagonal bordered pits. × 100.

Plate V.

Callitris calcarata.—A, Transverse section showing scattering resin cells and the rounded nature of the tracheides. × 70.

B, Radial section, showing the plates of thickening lying across the bordered pits. × 156.

C, Tangential section, showing the awns arising from the bordered pits projecting into the cavities of the cells. × 110.